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Land acquisition and resettlement action plan (LARAP) of Dam Project using Analytical Hierarchical Process (AHP): A case study in Mujur Dam, Lombok Tengah District-West Nusa Tenggara, Indonesia

Evi Kurniati [*,*], Alexander Tunggul Sutanhaji [a], Okti Ayu Anggraini [a]

[a]*Department of Agriculture Enginering, Faculty of Agricultural Technology, Brawijaya University, Jl. Veteran, Malang-East Java 65145, Indonesia*

Abstract

This research aims to develop Land Acquisition and Resettlement Action Plan (LARAP) of a dam project by using Analytical Hierarchical Process (AHP). In this research, AHP was applied to decide the best location for resettlement from two alternatives such as dam surrounding area and convenient area (mainly for farming). The best area was chosen based on its fitness with government's urban planning and the willing of people impacted. Systematically, this method covers formulating the main goals, identifying certain factors (objectives and sub-objectives), formatting and weighing the hierarchy of the factors, calculating AHP, and deciding alternatives. The main concerns are the benefit, cost and risk. Furthermore, each of the goals was based on economic, socio-culture, and environmental factors. The hierarchy of the chosen location was shown from its score, in which the best location holds the highest score. The result showed that the best location for resettlement at dam surrounding area was at Mujur village (0.12941), East Praya County while at the convenient area was Kawo village (0.11897) of Pujut County.

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Keywords: resettlement, dam, AHP

* Corresponding author. Tel.: +62-88-1332-7542; fax: +0-000-000-0000
E-mail address: evi_kurniati@yahoo.com

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1. Introduction

The Southern part of Lombok Island is less productive than the other areas due to little amount of rainfall (800mm/year) and lack of proper water resources. Dam project is expected to recover the area to be more productive in order to increase the people's prosperity. However, such this project often leads to other problems, and the most striking one is people's resettlement. Therefore, Land Acquisition and Resettlement Action Plan (LARAP) study should be implemented before the construction of a dam in order to have an accurate consideration about the advantages and disadvantages of the project to the people impacted. The whole study of LARAP included identifying socio-economic characteristics of the people impacted, holistic planning of the land acquittal, resettlement, and compensation scheme [1].

Mostly, LARAP study only requires that the resettlement areas should be as close as possible from the acquisition areas and the displaced people should be satisfied. Some require highest people density, easily developed area, high level of community participation, lowest number of lease and infrastructure, lowest environmental risks, and good transportation access [2]. Those criterias meet the standard for resettlement area. Analytical Hierarchical Process (AHP) method is considered as one of LARAP research methods that can be used to determine the resettlement area since this method offers clearer description of each alternative result.

This research aims to develop LARAP of a dam project by using AHP method. The best resettlement area is an area that is economically and environmentally beneficial for the people impacted. AHP has preferred capability to decide the best alternative from a series of hierarchy solution [3, 4, 5]. In this research, AHP is employed to decide the best location for resettlement from two alternatives such as dam surrounding area and dam convenient area (mainly for farming). The area will be chosen based on its fitness with urban planning and the willing of the people impacted.

The width of Central Lombok District is 1,208.39 sq.km and located at 116°05' to 116°24' BT and 8°24' to 8°5' LS. The northern part is hilly area around Rinjani Mountain, with fertile soil that makes it very suitable for farming. So is the center part. While, the southern part is lime hilly area arid faced straight to Hindi ocean. Renggung River is the main river that is recharged by Landai and Jembunut river (Fig.1). Its capacity depends much on the amount of rainfall. The climate type of the area is D with 200 mm/month rainfall during 3-4 wet months (November-march) and 100 mm/month rainfall during 6-8 dry season (April-October). Citified by ± 900,000 people, above 20% are categorized as poor.

The Mujur dam project is held in Mujur village, East Praya County, the southern part of Centre Lombok District. The flooded area is up to 214 hectares that will impact Mujur and Sukaraja village in East Praya County, Kelebuh village in Centre Praya County, and Loang Maka village in Janapria County (Fig. 2) with total number of 4,667 people to be impacted. The main dam is located in Mujur village, cutting up the Renggung River and will save 25.9 million cubic meters maximum. Beside the flooded area, Mujur dam needs 31 hectares to be used as both the main dam and supporting facilities.

Nomenclature	
F1, F2, F3	main goal for benefit, cost and risk aspect respectively
EV	Eigen vector
VP	vector priority
EV_{h1}, EV_{h2}, EV_{h3}	Eigen vector for main goal, objective and sub-objective level (also called HPV)
HPV	Hierarchical Priority Vector

2. The AHP Formulation

Systematic steps of the AHP formulation began with formulating the main goal, identifying certain factors, hierarchy formation and assessment, and alternative solution. The main goal of this analysis was to decide the best location for resettlement. It should be decided between two alternative locations i.e. dam surrounding area or dam convenient area (mainly for farming). The factors considered were benefits, costs, and risks aspect. The coding for benefit, cost and risk were F1, F2, and F3 respectively. The formulation of these elements is as follows:

$$Goal = Benefit / Cost \times Risk \quad (1)$$

The factors derived from each aspect of the main goals were then set into objectives and sub objectives level of hierarchy. The identification of these factors can be seen in Fig.3. Then these factor were weighed using F code as the hierarchy formation and assessment of AHP calculation. Weighing was based on its level of importance. At the main goal factor, the level was basically the same so weighing for each factor was 1. The next coding series were set as function of graded objective and sub-objective as is shown in Fig.3. Weighing for objective and sub objective level was based on subjective consideration from the researcher's point of view.

AHP calculation covers matrix development (Fig. 1.a), calculating Eigen vector (EV) (Fig.1.b) and vector priority (VP) (Fig.1.c).

$$M = \begin{pmatrix} F1/F1 & F1/F2 & F1/F3 \\ F2/F1 & F2/F2 & F2/F3 \\ F3/F1 & F3/F2 & F3/F3 \end{pmatrix} \quad (a)$$

Eigen vector (EV)

$$EV = \left(\sqrt[n]{N_{i1} \times N_{i2} \times N_{i3} \times \ldots\ldots \times N_{in}} \right) \quad (b)$$

Where: i = 1,2,3.....n

Vector Priority (VP)

$$VP_t = \frac{EV_i}{\sum EV} \quad (c)$$

Fig. 1. AHP calculation formulas: (a) matrix development, (b) Eigen vector (EV) and (c) Vector Priority (VP).

The Eigen vector (EV) value was then used to calculate Hierarchical Priority Vector (HPV) or EVh by using flow diagram in Fig.3. The h_1, h_2 and h_3 represented the level of main goal, objectives, and sub-objectives respectively. HPV value (Fig. 4) was then characterized into 5 interval classes showing the level of importance on sub objectives level. Importance classification was shown in Table 1.

Table 1. Importance classification for sub objective level

Importance classes	Value
Not important	< 0.00114
Less important	0.00114 – 0.00194
Important	0.00194 - 0.00274
More important	0.00274 - 0.00353
Very important	> 0.00353

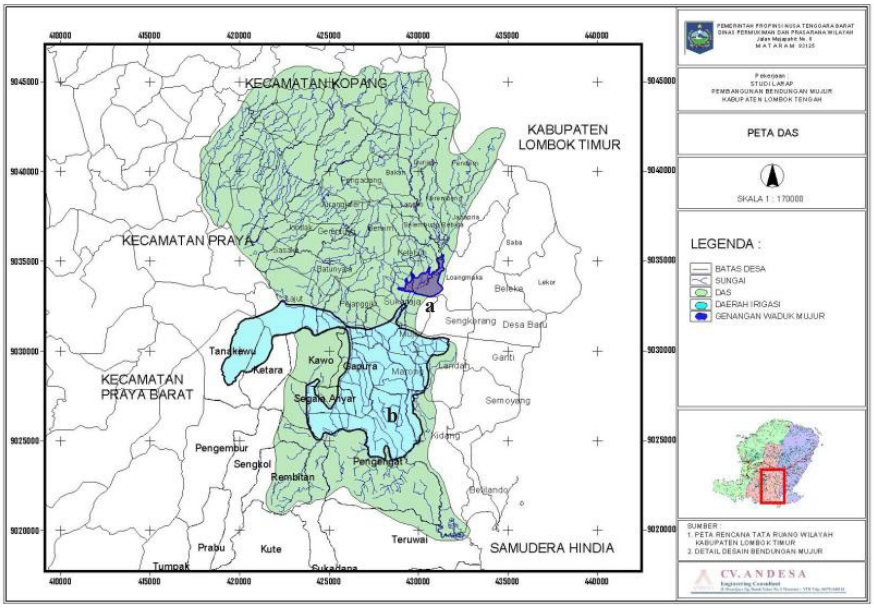
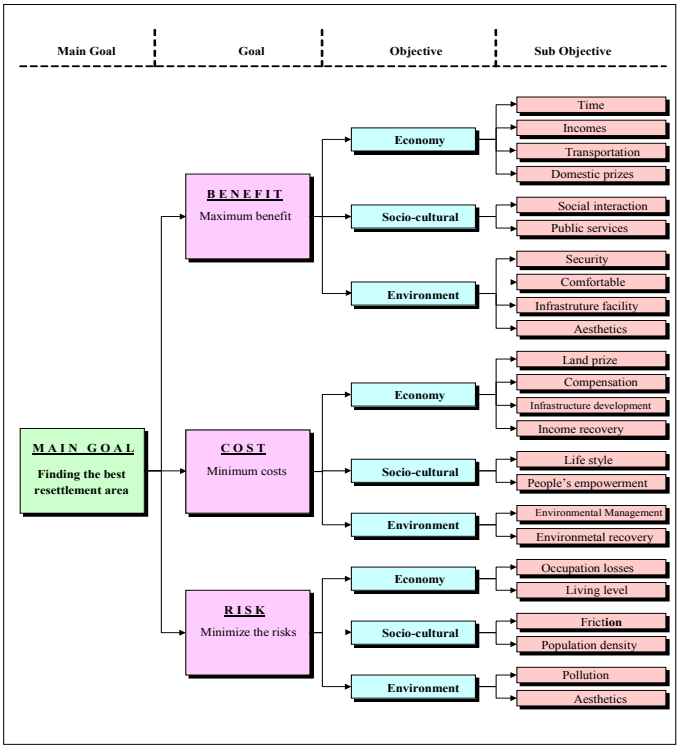


Fig. 2. Map of Renggung River watershed with Mujur dam flooded area (a) and benefit area (b).



Definition of sub-objectives

Sub-objectives	Definition	Scale (1-5)
Time	Time frame of complete resettlement	Slow, moderately fast, fast, faster, and very fast
Income	Potential income on the resettlement area	No income, decrease, steady, increase, and excelent
Transportation	Transportation cost to reach facilities	Very expensive, expensive, steady, cheaper, and very cheap
Domestic prizes	Comparative domestic prize with the resettlement area	Very cheap, cheap, steady, more expensive, and expensive
Social interaction	Social interaction with new neighbourhood	Distantly, moderately distant, firm, tight, and very tight
Public services	Acessability to public services	Very difficult, moderately difficult, easy, easier, and very easy
Security	Resettlement area security	Unsecure, less secure, secure, more secure, and very secure
Comfortness	Comfortness of living at the resettlement neighbourhood	Uncomfort, less comfort, comfort, more comfort, and very comfort
Infrastructure availability	Availability to have proper infrastructure	Not available, less available, available, more available, and very available
Aesthetics	Sight view beauty of the resettlement area	Not beautiful, less beautiful, steady, more beautiful, very beautiful
Land prize	Land prize comparing to resettlement area	Very expensive, more expensive, standard, cheaper, and very cheap
Compensation	Compensation for cost living during movement	Very expensive, more expensive, standard, cheaper, and very cheap
Infrastructure development	Cost for build new infrastructure	Very expensive, more expensive, standard, cheaper, and very cheap
Income recovery	Cost to people recovery the resettled people's income	Very expensive, more expensive, standard, cheaper, and very cheap
Life style	Cost of new life style	Wasteful, more wasteful, standard, simple, very simple
People's Empowerments	Paid cost to empower the resettled people	Very expensive, more expensive, standard, cheaper, and very cheap
Environmental management	Cost of environmental management	Very expensive, more expensive, standard, cheaper, and very cheap
Environmental recovery	Cost of environmental recovery	Very expensive, more expensive, standard, cheaper, and very cheap
Occupation losses	Occupation losses caused by resettlement	Few, moderately big, big, bigger, hudge
Living level	Prosperity alteration	Dive, decrease, steady, increase, rise up
Friction	Potetial friction with the new neighbourhood	Small, moderately threaten, threaten, more threaten, and very threaten
Population	Population increasing on the resettlement area	Rare, less dense, dense, more dense, and densely populated
Pollution Impact	Potential environmental pollution caused by resettlement activities	Small, moderately big, big, bigger, hudge
Aesthetics	Aesthetical impact caused by resettlement activities	Small, moderately big, big, bigger, hudge

Fig. 3. Certain factor identification and characterization

3. Result and Recommendation

Alternatives for resettlement areas were developed based on its fitness with government's urban planning (year 2006-2016) and the willing of the people impacted. People's opinion to decide the ideal resettlement area was delved in public consultation held in 3 counties that would be impacted. The calculation result and classification of sub-objectives level was shown in column 16 at Fig.4.

GOAL					OBJECTIVE					SUB OBJECTIVE					Importance Level
Factor	Weight	EV	VP	HPV	Factor	Weight	EV	VP	HPV	Factor	Weight	EV	VP	HPV	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
F 1	1	1.44	0.33	0.33333	F.1.1	4	1.35	0.14	0.04778	F 1.1.1	3	1.18	0.04	0.00208	Important
										F 1.1.2	4	1.57	0.06	0.00277	More important
										F 1.1.3	2	0.79	0.03	0.00138	Less important
										F 1.1.4	2	0.79	0.03	0.00138	Not important
					F 1.2	3	0.98	0.11	0.03471	F 1.2.1	2	0.79	0.03	0.00101	Not important
										F 1.2.2	4	1.57	0.06	0.00201	Important
					F 1.3:	3	1.02	0.11	0.03584	F 1.3.1	2	0.79	0.03	0.00104	Not important
										F 1.3.2	2	0.79	0.03	0.00104	Not important
										F 1.3.3	4	1.57	0.06	0.00208	Important
										F 1.3.4	1	0.39	0.01	0.00052	Not important
F 2	1	1.44	0.33	0.33333	F 2.1	5	1.69	0.18	0.05973	F 2.1.1	5	1.96	0.08	0.00433	Very important
										F 2.1.2	4	1.57	0.06	0.00346	More important
										F 2.1.3	5	1.96	0.08	0.00433	Very important
										F 2.1.4	4	1.57	0.06	0.00346	More important
					F 2.2	2	0.68	0.07	0.02389	F 2.2.1	1	0.39	0.02	0.00035	Very important
										F 2.2.2	4	1.57	0.06	0.00138	Less important
					F 2.3	3	1.02	0.11	0.03584	F 2.3.1	2	0.79	0.03	0.00104	Not important
										F 2.3.2	1	0.39	0.02	0.00052	Not important
F 3	1	1.44	0.33	0.33333	F 3.1	4	1.35	0.14	0.04778	F 3.1.1	4	1.57	0.06	0.00277	More important
										F 3.1.2	3	1.18	0.04	0.00208	Important
					F 3.2	2	0.68	0.07	0.02389	F 3.2.1	3	1.18	0.04	0.00104	Not important
										F 3.2.2	4	1.57	0.06	0.00138	Less important
					F 3.3	2	0.68	0.07	0.02389	F 3.3.1	2	0.79	0.03	0.00069	Not important
										F 3.3.1	1	0.39	0.02	0.00035	Very important

Fig. 4: Sheet of AHP calculation

Scoring of sub objective criteria for each village was obtained from a series of questionnaire arranged upon government's urban planning (year 2006-2016) and the willing of the people impacted. It was also scored based on defining sub objective scaling in Fig.2. Alternative solutions were decided based on the total score of each tested area, resulted from multiplying HPV value with each area's score. The best alternative area was one with the highest score. The proposed resettlement area were dam surrounding area, convenient area, or other places that was individually chosen. In this case, the calculation was only done to the surrounding and convenient area because they were the most chosen areas by the displaced people. The surrounding dam project area include 4 villages that are Kelebuh village in Center Praya County, Mujur and Sukaraja village in East Praya County, and Loang Maka village in Janapria County. The convenient area include 7 villages i.e. Pejagik and Lajut village at Center Praya County, Sengkerang and Marong village in East Praya County, and Kawo, Sengkol and Teruwai village in Pujut County. These areas were then categorized using sub-objective criteria in Fig.2 and component weight in Fig.4. Each score scale of the village was then multiplied with the sub-objectives HPV value (Column 15 in Fig. 4) to have priority score. Priority vector score of each village was the total score of sub-objectives criteria. The calculation result of priority vector for each village can be seen in Table 2.

Table 2. Priority vector calculation result for each village

Area	County	Village	Total score
Surrounding dam	Center Praya	Kelebuh	0.1135
	East Praya	Mujur	**0.1294**
		Sukaraja	0.1190
	Janapria	Loang Maka	0.1098
Convenient area	Center Praya	Pejagik	0.1180
		Lajut	0.1152
	East Praya	Sengkerang	0.1173
		Marong	0.1159
	Pujut	Kawo	**0.1190**
		Sengkol	0.1159
		Teruwai	0.1187

The best resettlement location for dam surrounding area is in Mujur village (0.1294), East Praya County while for the conventient area is Kawo village (0.119), Pujut County. The other alternatives could also be chosen for area with lower score. Mujur village as the best alternative for resettlement area surrounding the dams is 985 hectares wide with about 581 hectares for farming land, 80 hectares for perennial plantation, 231 hectares for public facilities (road, river and unemployed land), and 93 hectares for settlement area. It has a relatively flat topography (0-2%), 7.9 people per hectare in terms of population density, mostly tobacco and paddy farmers, good public facilities and good social interaction. Meanwhile, Kawo village is 822.2 hectares wide area, 3.9 people per hectare in terms of population density inhabited by people with relatively similar characteristics. This area is also suitable for resettlement area. The presence of displaced people is expected to develop the resettlement area.

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